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(71) Applicant: **GE MEDICAL SYSTEMS SA**
78533 Buc Cedex (FR)

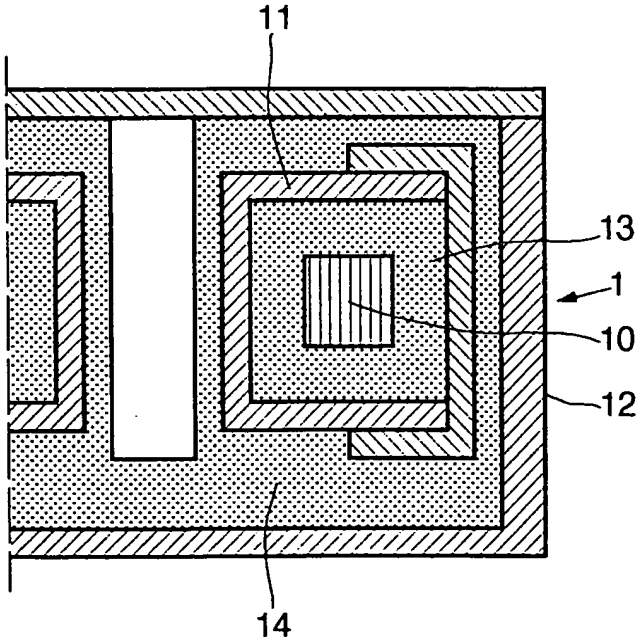
(72) Inventor: **Jedlitschka, Hans W. A.**
92320 Chatillon (FR)

(74) Representative: **Goode, Ian Roy**
GE LONDON PATENT OPERATION,
Essex House,
12/13 Essex Street
London WC2R 3AA (GB)

(54) Electrical insulation and cooling material for a high-voltage supply device

(57) Insulation and cooling material for high-voltage supply devices is a composite of at least one thermoplastic polymer and of at least one particulate ceramic filler so that the matieral has a thermal conductivity of at least 0.9 W/M.K. The thermoplastic polymer may be polypropylenes, poly (etherimides), poly(phenylsulphides) and poly(etherimide)/poly(phenyl-sulphide) mixtures. The particulate ceramic fillers may be alumina, aluminum nitride, boron nitride, barium suplhate and beryllium oxide and mixtures thereof.

The high-voltage supply device is intended for X-ray tubes.



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Description

[0001] The present invention relates to materials for insulating and for cooling high-voltage (HV) supply devices, in particular for the supply of X-ray tubes, and to the high-voltage supply devices incorporating these materials.

[0002] More particularly, the invention relates to novel insulation and cooling materials for high-voltage supply devices having an enhanced thermal conductivity in order to improve the dissipation of the heat generated in the device during its operation.

[0003] As is well known, X-ray tubes comprise a filament cathode which emits a beam of electrons towards an anode. Under the action of the bombardment by the electron beam, the anode emits a beam of X-rays. In order to obtain a high-energy electron beam, the electrons are accelerated by an intense electric field produced between the cathode and the anode. For this purpose, the anode is raised to a very high positive potential with respect to the cathode. This potential may exceed 150 kV. High-voltage supply devices are used to produce these potentials.

[0004] Generally speaking, the active components of the high-voltage supply devices are enclosed and supported in a first ribbed casing or surround made of an electrically insulating material and the first casing containing the active components is itself contained in a second casing which is made of metal and is earthed. The internal space of the first casing containing the active components as well as the space between the first casing and the second casing are filled with an insulating and cooling liquid, generally an oil.

[0005] More specifically, the active components of the high-voltage supply device in the first casing, such as the components of the high-voltage transformer, the rectifiers of the voltage doubler and all the conducting elements at various potentials, are mechanically held in place and electrically insulated from each other by being housed in different compartments in this first casing made of highly insulating material, such as electrically insulating plastics. The free space in this first casing is also filled with an insulating and cooling liquid such as an oil.

[0006] The oil-filled communicating free spaces inside the first casing and between the first casing and the earthed second casing constitute what is commonly called a high-voltage space.

[0007] The power necessary to operate an X-ray tube may be up to 25 kW to 100 kW for a few tenths of a second. Even when the high-voltage supply device has a very high efficiency, the power delivered by the device is limited by the temperature rise in the high-voltage space due to electrical losses in the active components. These losses may represent 6% of the output power. Typical power losses are of the order of several kilowatts.

[0008] In order to avoid thermal deterioration of the sensitive elements because of these power losses, it would be desirable to maintain the high-voltage space at a relatively low temperature.

[0009] An embodiment of the present invention therefore provides insulation and cooling materials for a high-voltage supply device having an enhanced thermal conductivity while maintaining the required electrical properties.

[0010] An embodiment of the invention also to provides a high-voltage supply device in which the oil-filled high-voltage space around the high-voltage active elements comprises a surround for insulating and for supporting the active components which is made of insulation and cooling material of the disclosed invention.

[0011] In an embodiment of the invention, an insulation and cooling material is produced for a high-voltage supply device, comprising a composite of at least one thermoplastic polymer and of at least one particulate ceramic filler so that the material has a thermal conductivity of at least 0.9 W/m.K.

[0012] The invention also relates to a high-voltage supply device that includes a surround for insulating and supporting the active elements, which is made of an insulation and cooling material according to the invention.

[0013] A high-voltage supply device to which the present invention may be applied is described in U.S. Patent Application No. 09/168,843. In brief, the high-voltage comprising the active components are placed in housings of a modular support, the side walls of which are formed by elements having overlapping complementary inclined surfaces providing both electrical insulation and thermal conduction.

[0014] The description refers to the single figure which shows a diagrammatic sectional view of a high-voltage supply device according to an embodiment of the invention.

[0015] The figure shows diagrammatically a high-voltage device 1 which conventionally comprises active components 10 immersed in oil and supported and insulated by one or more insulating surrounds 11 made of solid insulating material.

[0016] These active components 10 and the supporting and insulating surrounds 11 are themselves enclosed in a ribbed casing 12, for example made of aluminum, which is grounded.

[0017] The free spaces 13, 14 between the active components 10 and the insulating surround 11 and between the insulating surround 11 and the grounded casing 12, respectively, communicate with each other and are filled with insulation oil.

[0018] The electrical-insulation and cooling material of the surround 11 comprises a composite of at least one thermoplastic polymer and of at least one particulate ceramic filler so that the material has a thermal conductivity of at least 0.9 W/m.K.

[0019] The insulating surround 11 may be a multiple surround consisting of mutually overlapping elementary surrounds separated by spaces filled with insulation oil.

[0020] Although the insulating oils which are generally used in high-voltage supply devices have, in the absence of any applied electric field, thermal conductivities of about 0.115 W/m.K, it has been found that these same oils, because of the movement of the oil due for example to the application of the high electric fields present in the high-voltage supply devices or any other means, had very much higher thermal conductivities, these possibly being 30 to 100 times higher depending on the geometry of the device. It follows that, for thermal dissipation, the solid insulating material of the surrounds 11 is a determinant factor.

[0021] Any thermoplastic polymer making it possible to obtain the desired thermal conductivity of at least 0.9 W/m.K, which does not degrade the other desirable properties of the insulation and cooling material, such as the dielectric strength and the dielectric constant, may be used in the composite of the invention. In particular, the dielectric strength should be greater than 50 kV/mm and the dielectric constant between 2 and 4.

[0022] Furthermore, the insulating material should be such that it allows easy conversion, carried out on an industrial scale, for example by moulding, injection-moulding or extrusion, or any other conventional industrial process.

[0023] In order to facilitate the conversion, any conventional processing aid may be included in the material.

[0024] Among the polymers useful for formulating the composites of the present invention, mention may be made of polypropylenes, fluoropolymers such as polytetrafluoroethylenes (PTFE), polychlorotrifluoroethylenes (PCTFE) and poly(vinylidene fluorides) (PVDF), poly(amideimides) (PAT), poly(etherimides) (PET), poly (ethersulphides) (PES), poly(phenyl-sulphides) (PPS) and mixtures thereof.

[0025] The preferred polymers are polypropylenes, poly(etherimides), poly(tetrafluoroethylenes) and poly (phenylsulphides) and poly(etherimide)/poly(phenylsulphide) mixtures.

[0026] The particulate ceramic fillers useful in the formulation of the composites of the invention are all ceramics giving the composite the required thermal conductivity without degrading the other properties of the insulation and cooling material and in particular the electrical-insulation properties.

[0027] The preferred particulate ceramic fillers are alumina, aluminum nitride, boron nitride, barium sulphate and beryllium oxide, and mixtures thereof.

[0028] Boron nitride, aluminum nitride and mixtures thereof are more particularly recommended.

[0029] The amount of particulate ceramic filler of the composite is generally at least 40% by weight with respect to the total weight of the composite and is generally between 40 and 80% by weight, preferably from 40 to 60% by weight.

[0030] The particulate ceramic filler generally has a particle size of between 1 and 100 μm, preferably between 10 and 60 μm.

[0031] The particles of the ceramic filler may optionally be coated with a layer of another material that does not impair the thermal-conduction and electrical-insulation properties, such as a layer of silicone conferring lubrication on the particles.

EXAMPLE

[0032] An insulation and cooling material according to the embodiment of the invention was prepared, by simple mechanical mixing, which comprises, by weight, 30% of poly(phenylsulphide), 30% of poly(etherimide), 25% of aluminum nitride powder and 15% of boron nitride powder.

[0033] The material was injection-molded, a disc-specimen 60 mm in diameter and 4 mm in thickness was produced and the properties below were determined:

Thermal conductivity (75°C): > 0.96 W/m.K

Breakdown strength: > 70.5 kV/mm

Dielectric constant: 3.4 (1 kHz, 75°C).

[0034] Various modifications in structure and/or function and/or steps may be made by one skilled in the art to the disclosed embodiments without departing from the scope and extent of the invention.

Claims

1. Material for a high-voltage supply device, comprising a composite of at least one thermoplastic polymer and of at least one particulate ceramic filler so that the material has a thermal conductivity of at least 0.9 W/m.K.

2. Material according to claim 1, wherein the composite comprises at least 40% by weight, with respect to the total weight of the composite, of particulate ceramic filler.

3. Material according to claim 2, wherein the particulate ceramic filler represents 40 to 80%, preferably 40 to 60% by weight of the composite.

4. Material according to any one of claims 1 to 3, wherein the thermoplastic polymer is chosen from among polypropylenes, poly(tetrafluoroethylenes) and poly(etherimides).

5. Material according to any one of claims 1 to 4, wherein the particulate ceramic filler is chosen from among alumina, aluminum nitride, boron nitride and mixtures thereof.

6. Material according to claim 5, wherein the particulate ceramic filler is chosen from among aluminum nitride, boron nitride and mixtures thereof.

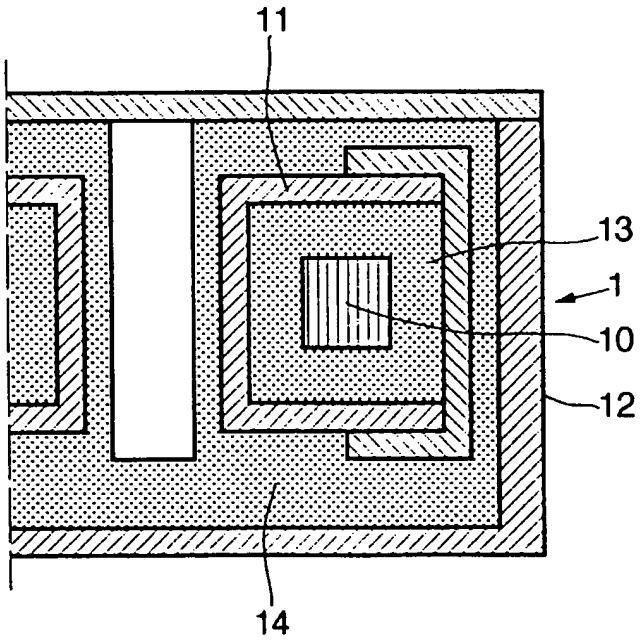
7. Material according to any one of claims 1 to 6, wherein the particulate ceramic filler has a particle size of between 10 and 60 µm.

8. Material according to any one of claims 1 to 7, wherein the material has a dielectric strength of at least 50 kV/mm.

9. Material according to claim 8, wherein the material has a dielectric strength greater than 50 kv/mm and a dielectric constant between 2 and 4.

10. High-voltage supply device comprising high-voltage active components (10) supported and electrically insulated in the device by means of a surround (11), wherein the surround is made of the composite material according to any one of claims 1 to 8.

11. Supply device according to claim 9, wherein the surround is a multiple surround formed from several mutually overlapping elementary surrounds separated by an insulating oil.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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 7849

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 January 2000	Capostagno, E

CATEGORY OF CITED DOCUMENTS

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FPO FORM 1503 03.82 (P04C01)

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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 7849

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X : particularly relevant if taken alone
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